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9th NASA Space Exploration and Space Weather Workshop

Joseph C. Hunt Jr.
Spitzer Deputy Mission Manager / Flight Director

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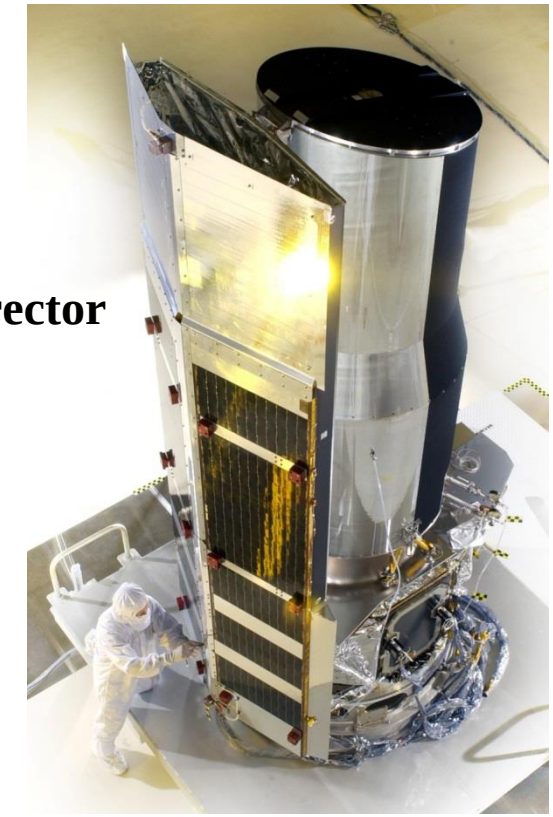
Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, CA 91109-8099 USA



Agenda

- **Mission Overview**
- **Space Weather Monitor Sources**
- **Operational Space Weather Process**
- **Summary of Key Events**
- **Summary**

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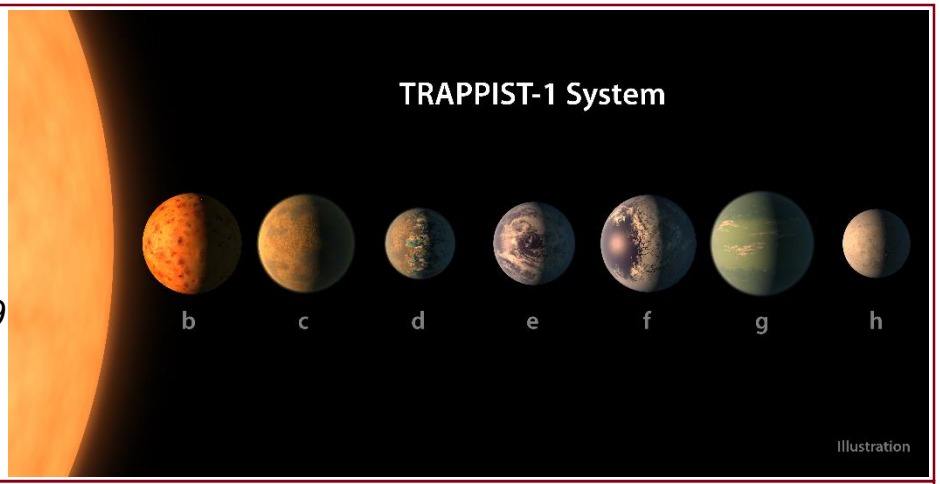
Mission Overview

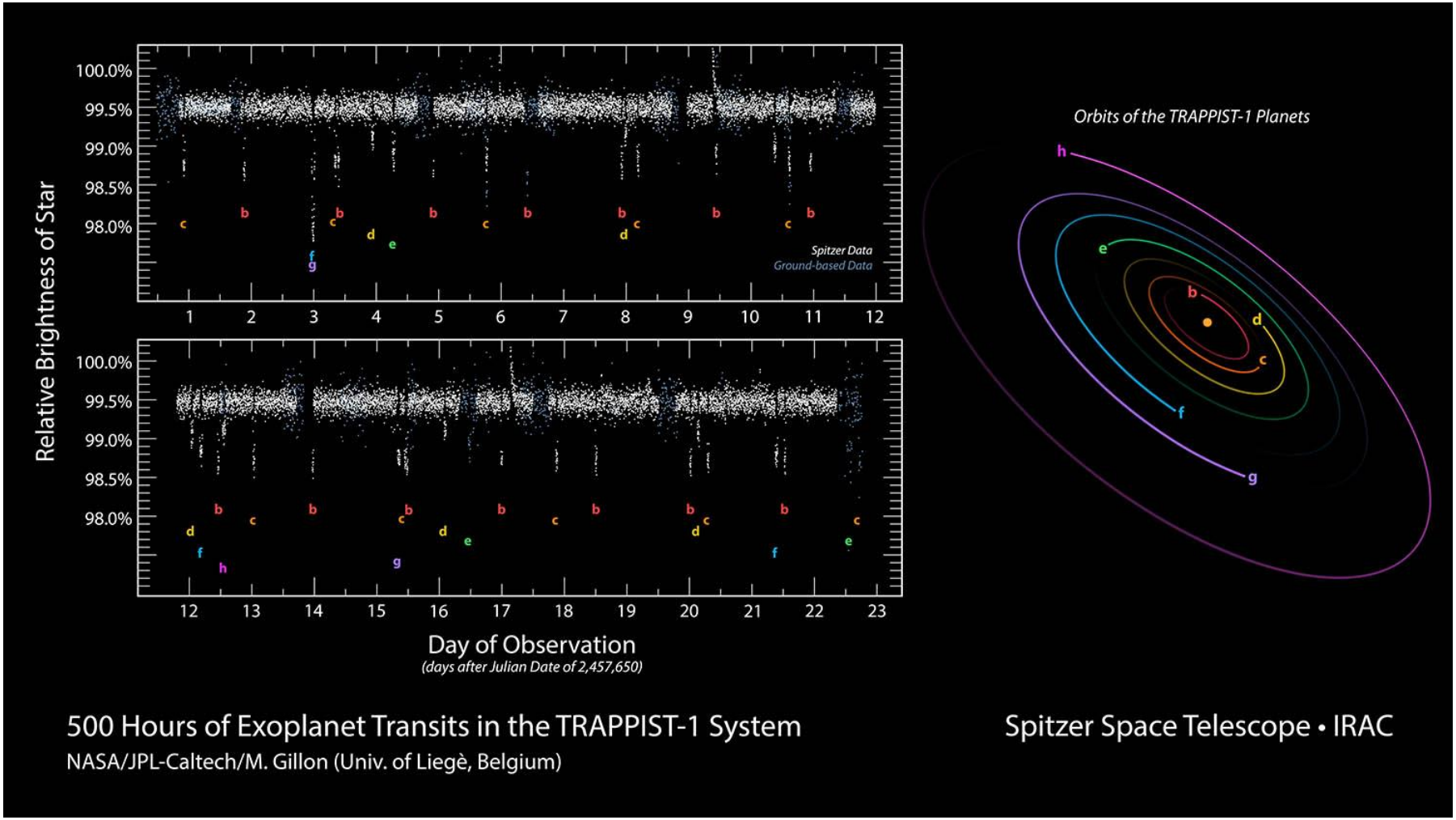
Salient Features

- *Class: B*
- *Category: 2*
- *Heliocentric orbit trailing the Earth*
- *85 cm Beryllium telescope operating at 26K*
- *2 arrays with 3-5 micron wavelength coverage*
- *Launch: 25 Aug 2003, Warm Mission: 27 July 2009*
- *Beyond Mission: 1 Oct 2016 - 31 March 2019*
- *100% community observatory*



Science

- *To study the properties of extrasolar planets and search for super-earths around nearby solar-type stars.*
- *To study galaxies as they were when the Universe was less than 1 Gyr old, and to understand how galaxies and clusters of galaxies have evolved with cosmic time.*
- *To complete the census of the Galaxy for young stars, star forming regions and dusty post-main sequence stars, and search for new classes of brown dwarfs and super-planets.*
- *To determine the cosmic distance scale in the local Universe with unprecedented precision by the first systematic application of mid-infrared observations to this critical problem.*



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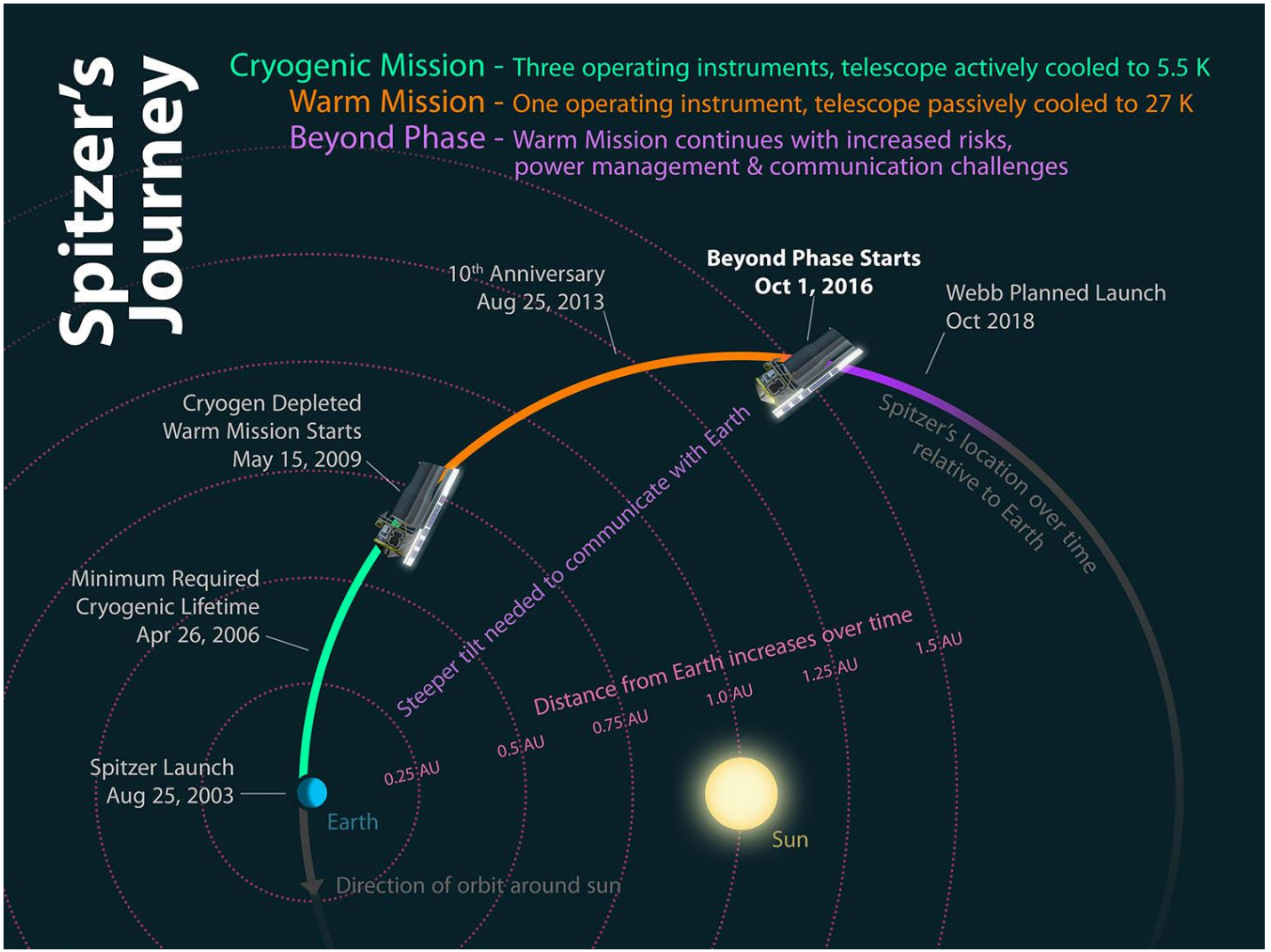
Mission Phases



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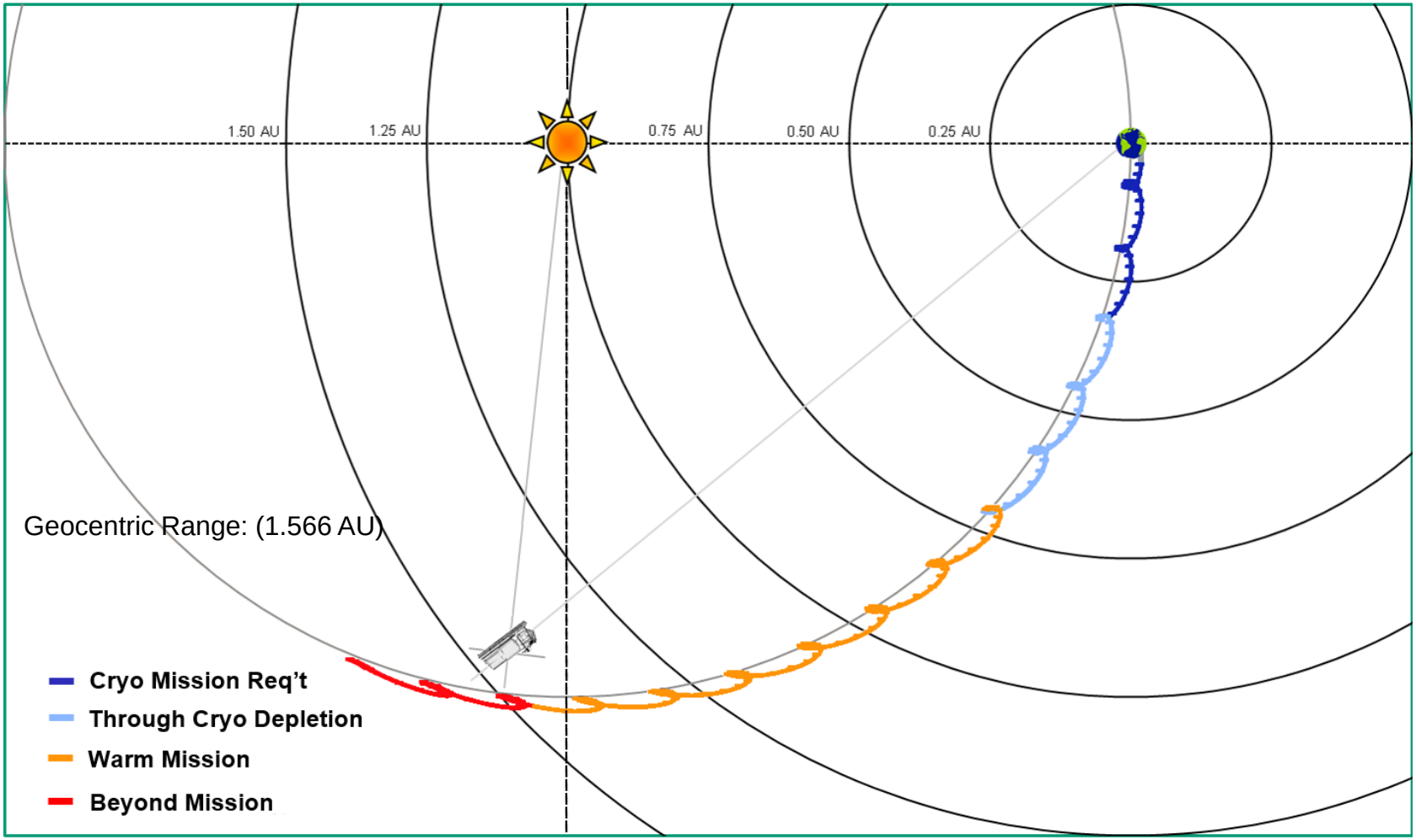
Spitzer's Orbit



Spitzer follows the Earth around the Sun. Its orbit is slightly more elliptical than the Earth's and it slowly recedes from Earth at about 0.1 AU/yr.

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Ground Segment Requirement

Launch and Cryo Mission Phase

Space Weather event producing protons exceeding the 100 MeV energy level and particle flux greater than 100 pfu

- The Ground Segment, using both local and telemetry information, shall decide the time at which the Observatory is to resume science operations after a solar flare
  - *real-time or stored sequence commands to accomplish this.*

- The Ground Segment shall recognize and respond to a solar flare event within 12 hours of occurrence
  - *powering off unprotected science loads as necessary to minimize radiation effects*.

Warm/Beyond Mission Phases

- Monitor and annotate for S/C and science performance impacts or degradation.
  - *ground operation provide notification*

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Space Weather Monitor Sources

- **GSFC SWRC-Space-Weather-Research-Center**
  - *SWRC Alerts*
  - *SWRC Model with Spitzer's coordinates*
  - *SWRC Summary Reports*

- **NOAA GOES**
  - *After more than twelve years of drifting away from the Earth, Spitzer's distance from Earth is ~1.38 AU, and the GOES satellites no longer serve as a predictive tool for the S/C however, may provide ground transmission possible impacts.*

- **STEREO A/B**
  - *During Spitzer's prime mission phase, STEREO-B and Spitzer shared the same heliocentric Right Ascension ,no longer applicable. STEREO-A is approaching in right Ascension and could provided useful data to support alerts.*

- **SPITZER**
  - *Mass Memory Card, Power Subsystem, Star Tracker, and IRAC instrument have proven to exhibit behavior that directly correlates to space weather events.*

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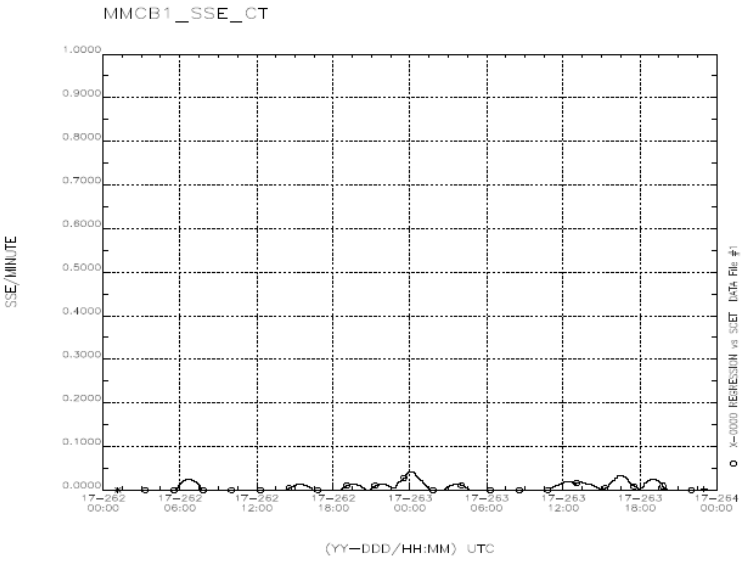
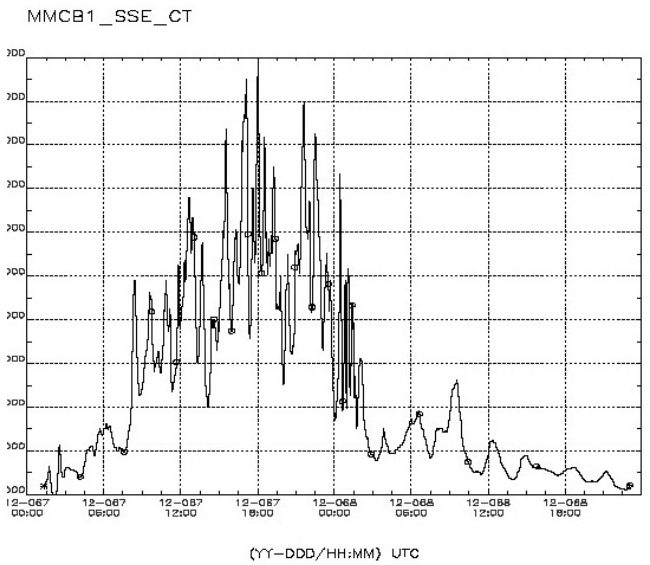
Mass Memory Card (MMC) Soft Scrub Errors

The EDAC continues to correct for single bit errors due to background radiation. The corrections are summed by the ratio of corrupted bits over time.

Increased background "noise" and the rapid changes in soft scrub error rates are indicative of space weather events.



Spitzer MMC Board 1 Soft Scrub Error Counts during September 19 - 20, 2017 CME Event.



Spitzer MMC Board 1 Soft Scrub Error Counts during March 7-8, 2012 CME Event.

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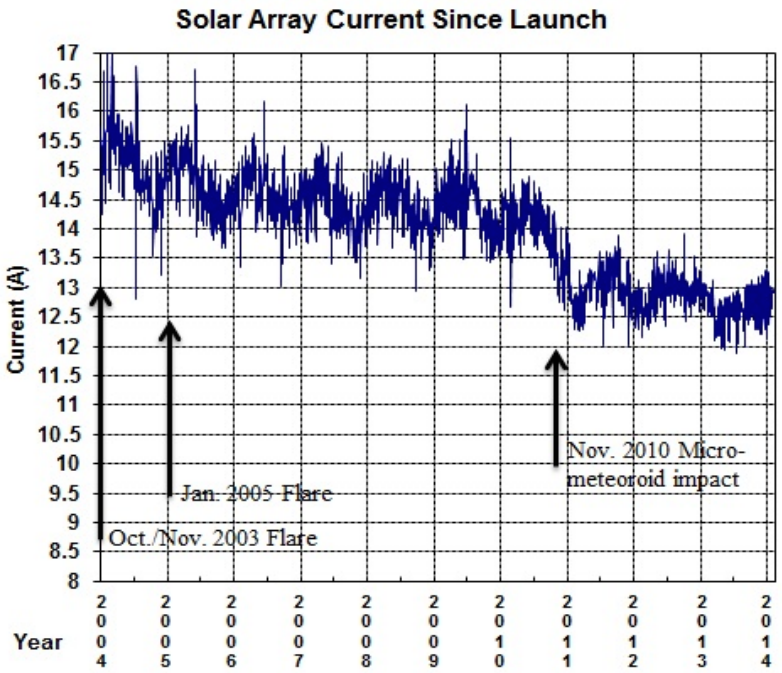
Power/Solar Array Panel

Continuous trending provides performance statics for the output power.



Major solar weather events in October-November 2003 and January 2005 reduced the solar panel assembly output by 4.7% and 2.8%, respectively. In addition, in early November 2010, a micrometeoroid impact damaged one of the solar panel assembly's strings, reducing the total power output by an additional 6.5%. The solar panel still operates well within the power output margin.

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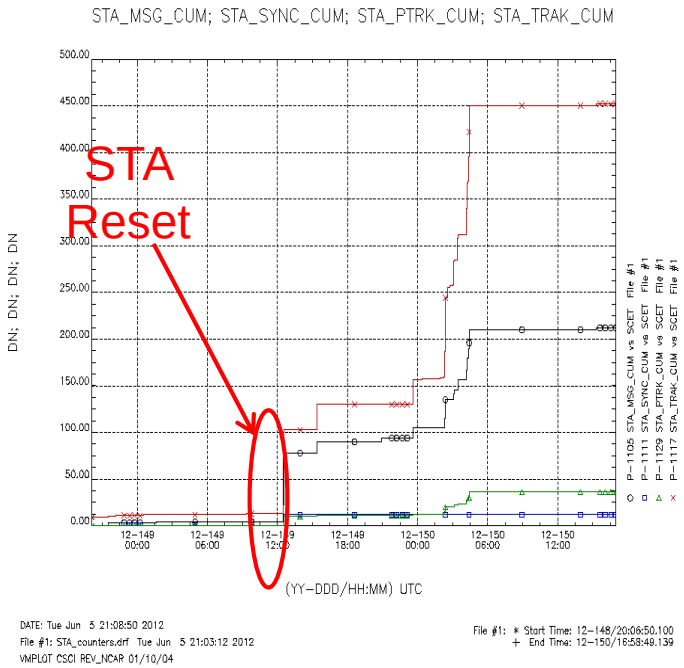
Star Tracker

STA component-level fault protection utilizes a series of checks to test the component health. Values are set to monitor counters for fault persistence



The accumulated and cumulative counts increased resetting the STA. This correlated with the May 2012 space weather event.

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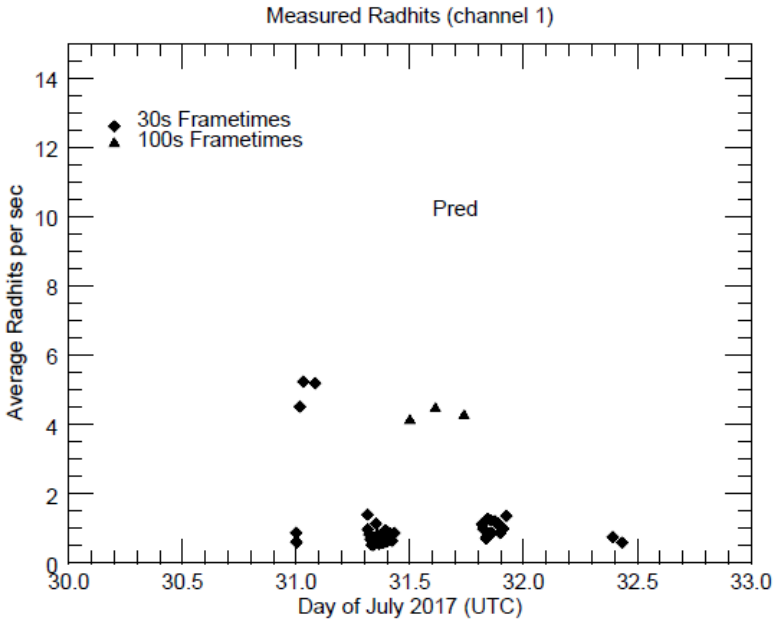
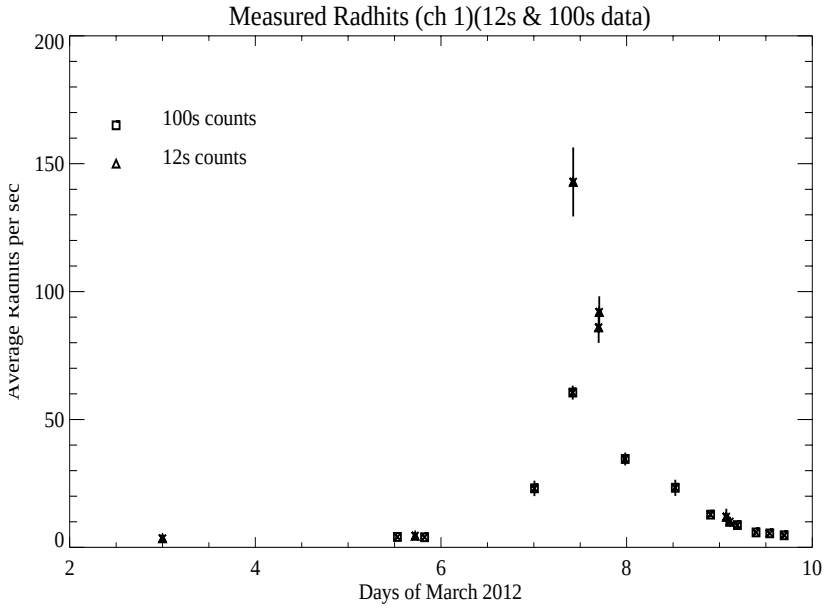
Infrared Array Camera (IRAC) Radhits

Based on the instrument exposure time the nominal observed Radhits are 4 per second with very little scatter.



(No functional impact to the Instrument, however IRAC saw a small impact from the CME (ID: 2017-07-28T16:24:00-CME-001)



(No functional impact to the Instrument, however Loss of 69.6 hours of Science data for the space weather event on DOY 067/2012).

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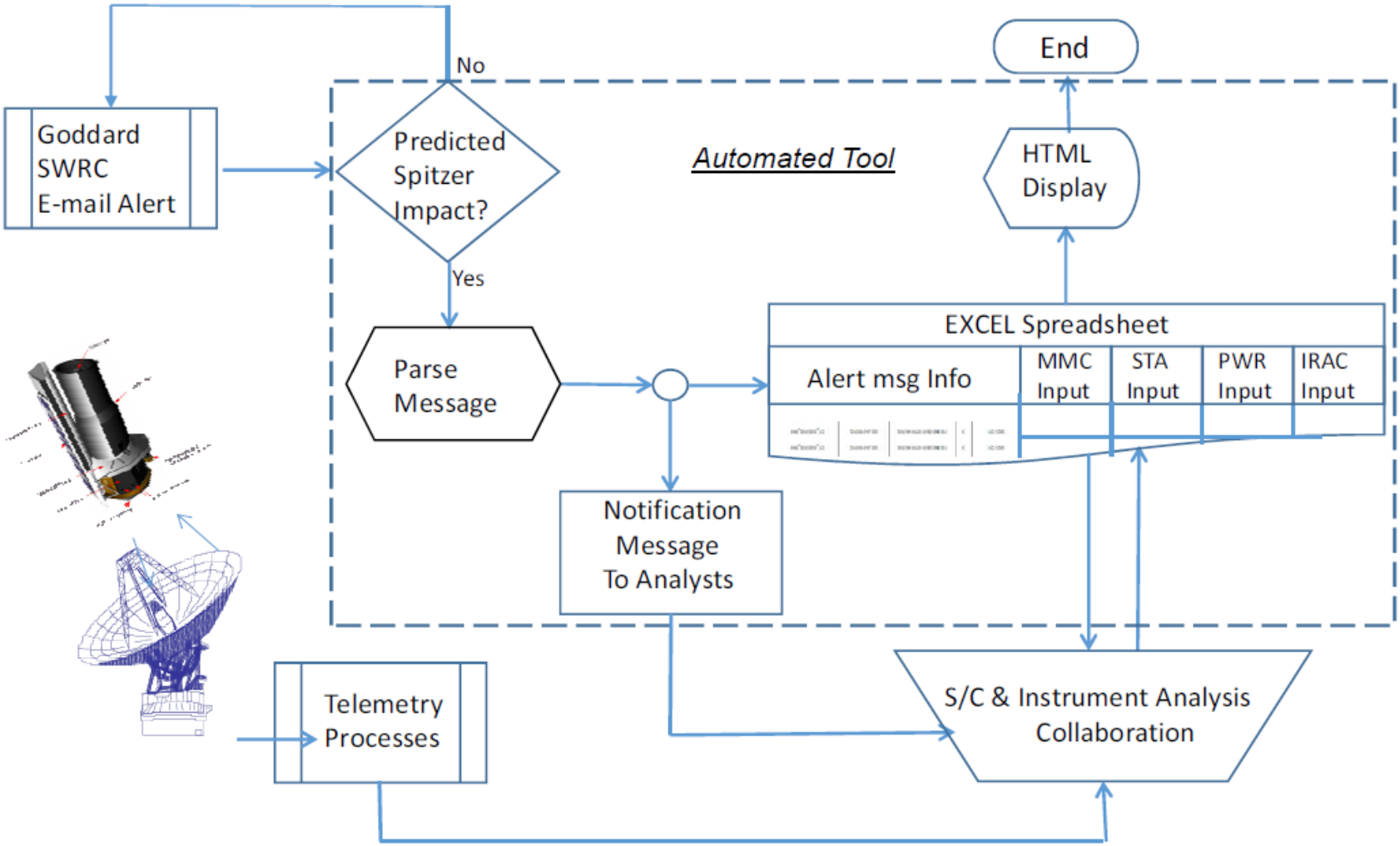
Space Weather Process



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Collaborative HTML Page

Item	Title	Message ID	Activity ID	Class	Edge Time	Alarms	MMC Soft Scrub Errors	Star Tracker	Power	IRAC
1	SWE_2017-09-18_262	20170918-AL-003	2017-09-17T14:24:00-CME-001	O	262 / 0220	No	Nominal			
			2017-09-17T12:09:00-CME-001	C						
2	SWE_2017-09-17_263	20170917-AL-004	2017-09-17T12:09:00-CME-001	O	263 / 000	No	Nominal	No	No	No
3	SWE_2017-07-28_212	20170728-AL-002	2017-07-28T05:36:00-CME-001	C	212 / 01621	No	Nominal	No	No	Small
4	SWE_2017-06-29_183	20170629-AL-001	2017-06-28T16:24:00-CME-001	S	183 / 0120	No	Nominal	No	No	Small
			2017-06-28T15:24:00-CME-001	S						
5	SWE_2017-04-19_111	20170419-AL-003	2017-04-18T19:48:00-CME-001	C	111 / 0226	No	Nominal	No	No	No
6	SWE_2017-01-03_006	20170103-AL-001	2017-01-03T03:12:00-CME-001	C	6 / 0731	No	Nominal	No	No	No
8										
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Summary of Key Events to Date

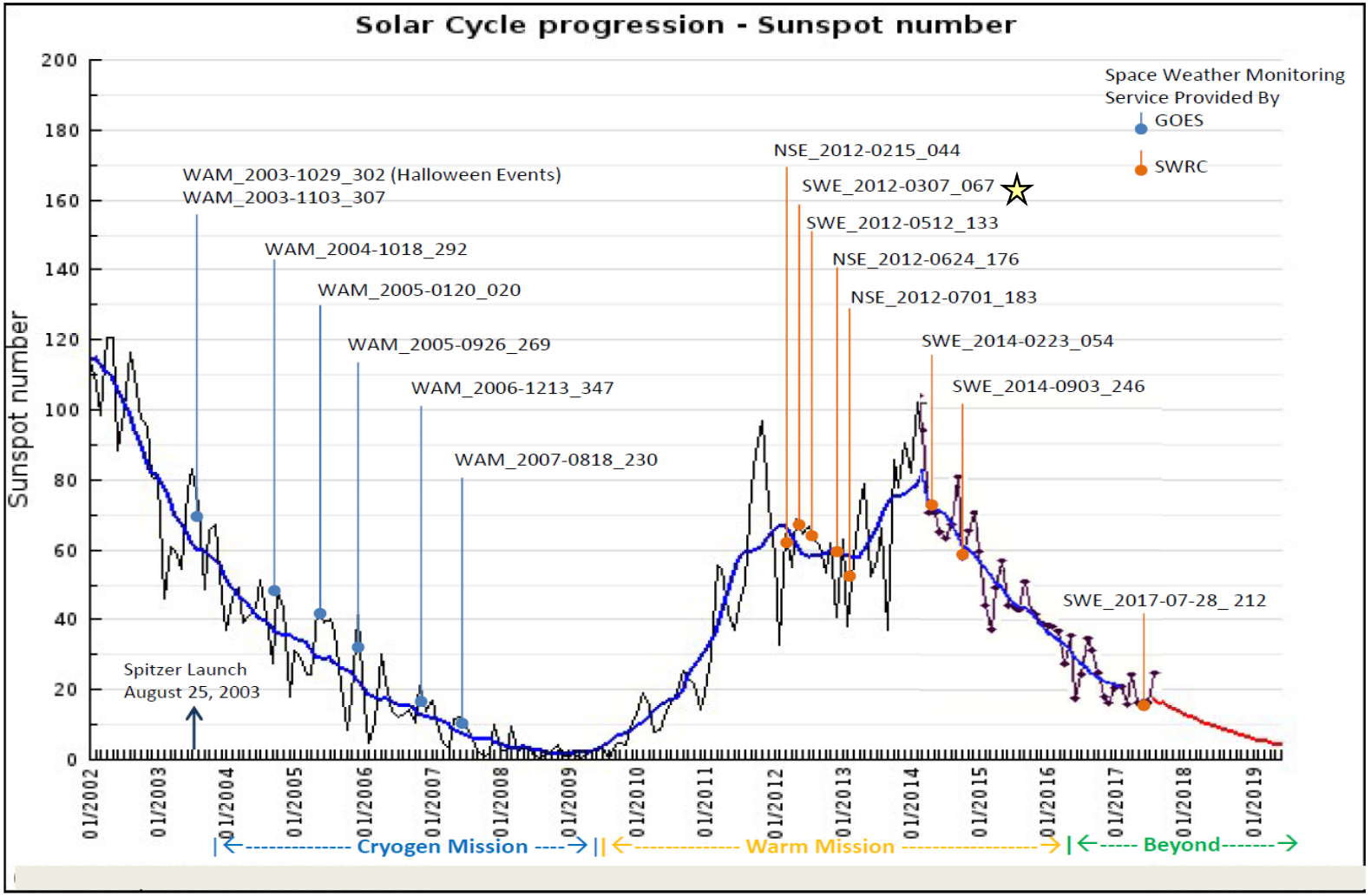

Table of Key Events

INPUT	IMPACT RESULTS			
Title	MMC	Star Tracker	Power	IRAC
WAM_2003-1029_302	Board 0 & 1 SSE	Noise + WASS Errs	SA pwr degraded	Increased Noise
WAM_2003-1103_307	Board 0 & 1 SSE	Noise + WASS Errs	SA pwr degraded	Commanded Off
WAM_2004-1018_292	Board 0 & 1 SSE	No	No	No
WAM_2005-1020_020	Board 0 & 1 SSE	No	No (CTA temp inc)	(IRS – Inc. Noise)
WAM_2005-0926_269	Board 0 & 1 SSE	No	No	No
WAM_2006-1213_347	Board 0 & 1 SSE	No	No (CTA temp inc)	Commanded Off
WAM_2007-0818_230	Board 1 SSE	No	No	No
NSE_2012-0215_044	Board 1 SSE	No	No	No
SWE_2012-0307_067	Board 0 & 1 SSE	No	No	Lost Science Data
SWE_2012-0512_133	Board 0 SSE	No	No	No
NSE_2012-0624_176	No	No	No	Increased Noise
NSE_2013-0201_041	Masked by IDIO	Dropped Acq	No	Increased Noise
SWE_2014-0223_054	Board 0 & 1 SSE	No	No	Increased Noise

Summary

- The Observatory remains in excellent health

Spitzer continues to deliver outstanding science.

- Mission Operations continues to utilize SWRC services
  - Feedback from Ops teams is the visualization model with the S/C embedded is useful

- Collaboration of user community for space weather events via “DONKI”
  - How do we manage NASA’s missions proprietary data ?

- Possible enhancements:
  - Life cycle chart of solar progression vs selected events

Acknowledgement

Thanks to Goddard's SWRC for continued services which has provided outstanding support to the interplanetary user community.

A large number of people from the Spitzer project, support organizations at the Jet Propulsion Laboratory, Lockheed Martin Space System Company, and the Spitzer Science Center at the California Institute of Technology contributed to the operations described herein.

Backup Material

Instruments

- Three science instruments
  - *IRAC – Infrared Array Camera*
    - Bands: 3.6 µm, 4.5 µm, 5.8 µm, and 8.0 µm
  - *MIPS – Multi-band Imaging Photometer*
    - Bands: 24 µm, 70 µm, and 160 µm
  - *IRS – Infrared Spectrometer*
    - Bands: 5.2 µm – 14.5 µm, 9.9 µm – 19.6 µm, 14.0 µm – 38.0 µm, and 18.7 µm – 37.2 µm
- In the Cryogenic Mission, only one instrument was on at a time for a sequence duration of one to three weeks.
  - *Primary mirror operates between 5.6 K and 12 K.*
- In the extended Warm Mission, only two bands of IRAC, 3.6 µm and 4.5 µm, will produce valid science data.
  - *Primary mirror operates at ~26 K*